EXP-18
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ACCELERATOR EXPERIMENT--Missing Bunches in the Booster

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General Considerations:

On some pulses the beam intensity signal in the booster shows losses as shown in curves (b) and (c). Previous observations by Peters and others have shown that these losses occur only in some of the 84 beam bunches in the booster and not others. The effect comes and goes for reasons which are not yet clear. The losses always occur during a time interval a few milliseconds wide immediately preceding transition. They cease when transition is reached and are not affected by the tuning of the transition phase jump.

Experimental Observations:

1. The booster was accelerating beams of 10-15 mA with up to ~7 GeV for the purpose of injection into the main ring.

2. The beam intensity vs. time signal (output of the 50 MHz beam transformer) was displayed on an oscilloscope, as well as the radial position vs. time (from the pick-up electrodes for the radial rf feedback). The two signals looked like those in Fig. 1.

3. In the standard operation mode, the radial position of the beam was set up according to the curve (1). For purposes of extraction,

it was requested that the beam be displaced at the top energy by ~0.5 cm outward. The beam was observed to be stable with no measurable losses when approaching the transition (except in very few pulses).

4. By adjusting the offset of the radial feedback, we moved the beam, first, outward by about 0.4 cm, taking care to make the radial position signal flat [curve (2) in the figure], and, then, inward, again by about 0.4 cm and still making the radial position signal flat [curve (3) in the figure]. In the first case, the number of pulses with the losses just before transition [curve (b)], characteristic of the "missing bunches," seemed to increase, although by only a small amount. In the second case, the beam was exceptionally stable: all the pulses observed looked like the curve (a).

5. We moved the beam again 0.4 cm, outward [curve (2)], but we applied also a local kick [curve (2a)] over about 100 turns and 5 ms from injection. The "missing bunches" effect, causing the beam loss a few milliseconds before transition, reappeared with drastic suddenness. Almost all the beam intensity signals looked like curves (b) and (c). Nevertheless, we did not observe any beam loss when the peak current was less than 12 mA, and the onset of the loss seemed to move earlier in time as the intensity loss increased. Curve (a) was typical of pulses with 12 mA or less, curve (b) typical of pulses around 13 mA and curve (c) of pulses of 14 mA or more.

The beam behaviour did not change by flipping the kick up or down [curve (2a)]. Typical value of the displacement caused by the kick is 3 mm. The number of pulses with "missing bunches" seemed to be correlated with the height of the kick. Also, the probability of beam loss with the beam programmed to the outside as in curve (2) was dependent on the radial offset used during the initial rf bunching process.

6. At this point we moved the beam again inwardly as shown in curve (3). We applied, also, the kick with the same height and width and at the same time (curve 3a). We flipped the kick up and down. The beam remained very stable.

7. In conclusion, the losses seem to depend on the radial position, but when the radial position is not constant throughout the pulse, the dependence is complicated and not always reproducible.

Experiment Proposal:

It might be interesting to check if the stability of the beam is in correlation with the sextupole field across the ring. Indeed, if it is so, we can explain the beam behaviour when the radial position is changed. For this purpose, we plan to install several (~12) air-core sextupole magnets of the type employed in the main ring. Unfortunately, these magnets can be located only at low-β_x and low X_p straight sections where

$$\beta_x \sim 7 \text{ m} \quad \text{and} \quad X_p = 1.8 \text{ m}.$$

We calculated the "chromaticity" correction of 12 of these sextupoles (60 cm long and ±15 kG/m^2 strong). We obtained, around the transition energy and for $\nu_x = 6.7$,

$$\zeta = \frac{\Delta\nu/\nu}{\Delta p/p} \sim \pm 0.1.$$

Will this correction be enough?

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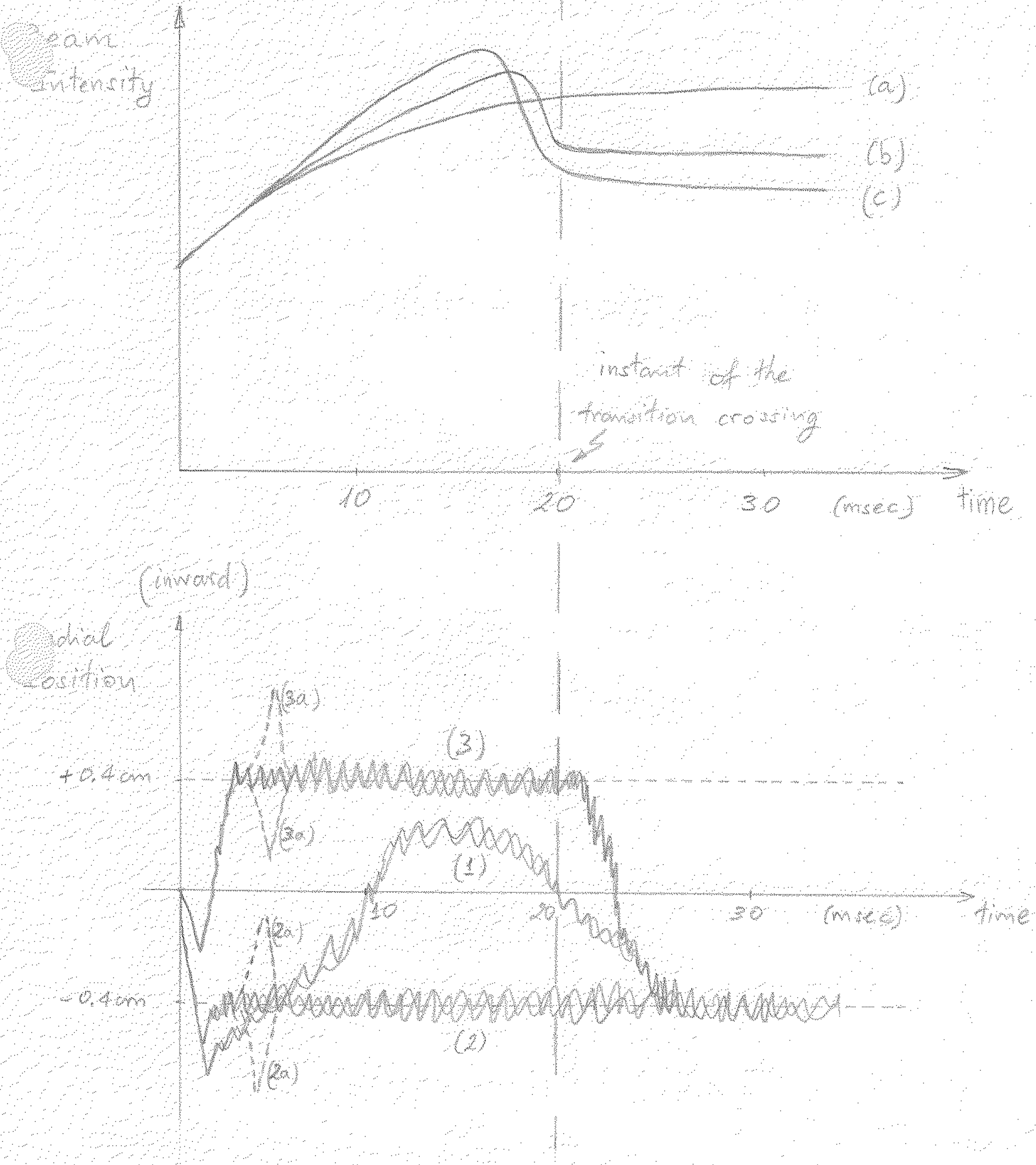
Beam Intensity
(a)
(b)
(c)
instant of the transition crossing
10
20
30
(msec)
time
(inward)
Radial Position
(3a)
(3)
+0.4cm
(3a)
(1)
10
20
30
(msec)
time
(2a)
-0.4cm
(2)
(2a)

FIG. 1